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BIOLOGY
HIGHER LEVEL
PAPER 3

Tuesday 18 May 2010 (morning)

1 hour 15 minutes

Candidate session number

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INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

0124

Option D — Evolution

D1. The HIV virus has a high rate of mutation. Scientists studied the evolution of this virus in a small group of men with a slow rate of disease progression for a period of 12 years. The viral divergence from the original viral population and the diversity within the populations were recorded over the years.

GRAPH REMOVED DUE TO COPYRIGHT REASONS.

(This question continues on the following page)

(Question D1 continued)

(a) (i) Identify the pattern of divergence of the viral sequence from the original viral population. *[1]*

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(ii) Identify the change in the pattern of diversity of the populations. *[1]*

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(b) Estimate the percentage increase of the population diversity from the stage of the initial infection to the diversity 12 years later. *[2]*

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(c) Using the data provided, suggest how the change in divergence and diversity of viral RNA may be of evolutionary benefit to the HIV virus. *[2]*

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D2. (a) Identify **two** processes needed for the spontaneous origin of life on Earth. *[2]*

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(b) Outline ideas about the pace of evolution according to gradualism and punctuated equilibrium. *[2]*

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(Question D2 continued)

(c) (i) Define a *clade*. *[1]*

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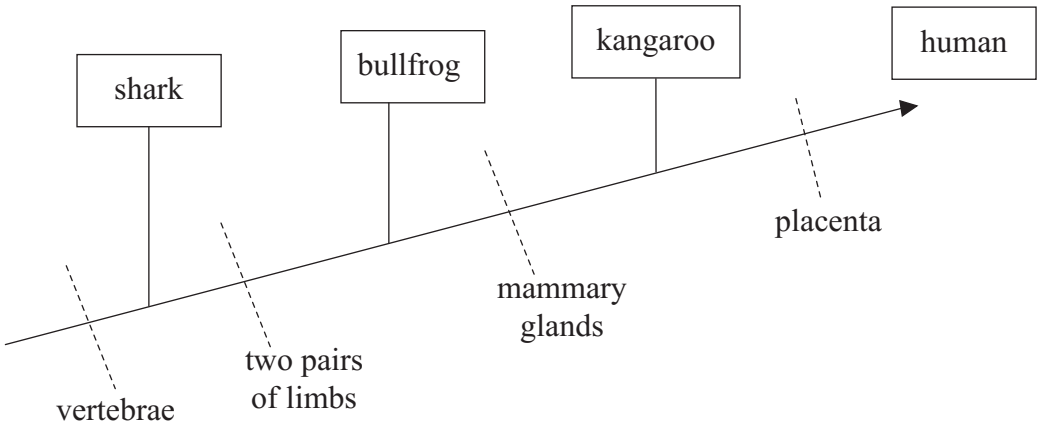
(ii) Analyse the relationship between the organisms in the following cladogram. *[3]*



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D3. Explain the biochemical evidence provided by DNA and protein structures for the common ancestry of living organisms. *[6]*

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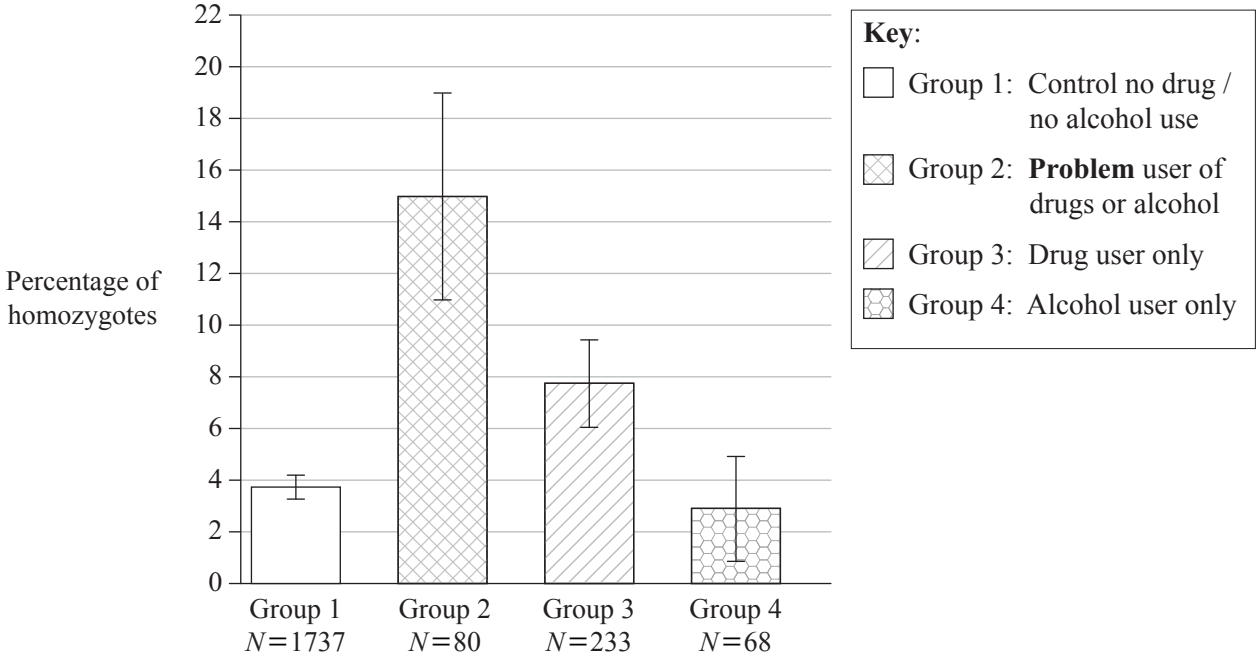
Option E — Neurobiology and behaviour

E1. Drug abuse and alcohol abuse are neurobehavioural disorders of complex origin. A human gene has been identified that encodes the main enzyme (FAAH) for inactivating cannabinoid (THC). A mutation in this gene can occur and the homozygous mutation allows normal catalytic activity of FAAH but makes the FAAH more likely to be broken down. A study was conducted to test for the presence of the homozygous FAAH mutation in relation to drug and alcohol abuse. Four different groups were formed based on their use of drugs and alcohol.



[Source: adapted from JC Sipe *et al*., "A missense mutation in human fatty acid amide hydrolase associated with problem drug use" (2002) *PNAS*, **99**(12), pages 8394–8399: Figure 1 (adapted). copyright 2002 National Academy of Sciences, USA]

(a) Identify the percentage of homozygotes among drug users only. *[1]*

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(b) Calculate the actual number of homozygotes in group 2. *[2]*

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(This question continues on the following page)

(Question E1 continued)

(c) Evaluate the evidence to support the hypothesis that the presence of the homozygous mutation is a risk factor in drug and alcohol use. *[3]*

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(d) Suggest a reason for the high incidence of homozygotes among drug and alcohol users. *[1]*

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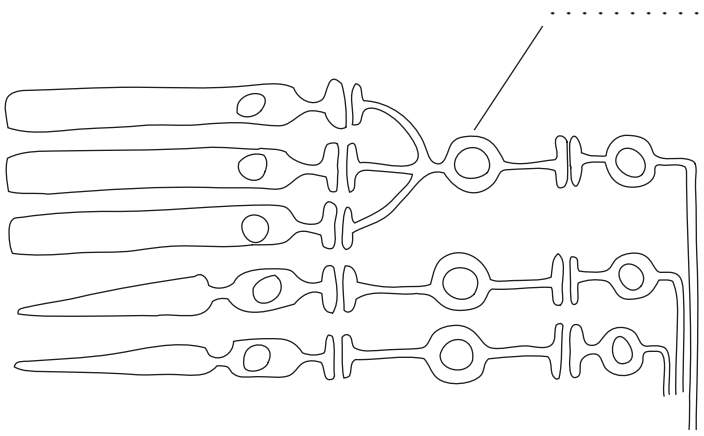
E2. (a) (i) Label the cell type indicated on the diagram below depicting part of the retina. *[1]*



(ii) Explain contralateral processing of visual stimuli. *[2]*

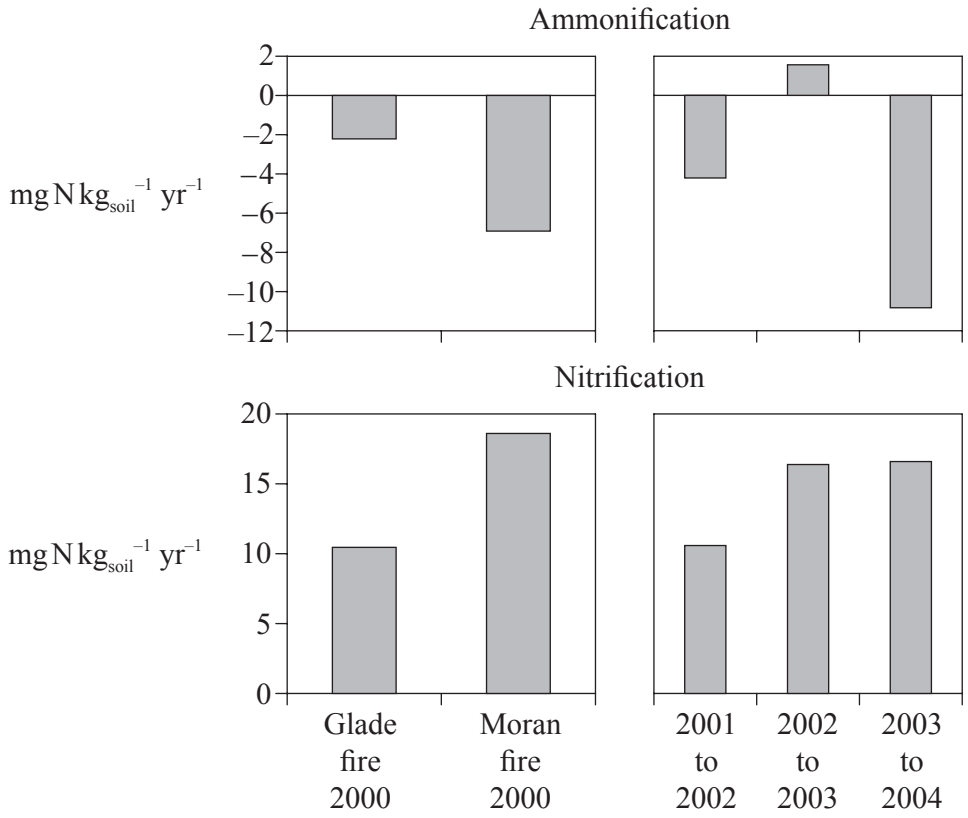
(b) Outline an example of the effect of natural selection on animal responses. *[2]*

(c) Using a **named** example, outline a rhythmical behaviour pattern with an adaptive value. *[2]*

E3. Explain sympathetic and parasympathetic control of blood flow to the gut. *[6]*

Option F — Microbes and biotechnology

F1. In the year 2000, serious fires damaged two regions in Yellowstone National Park, USA. In the Glade fire there was destruction to the tops of trees while the Moran fire destroyed ground level species. After these fires, the overall nitrogen levels for ammonification (formation of ammonia) and nitrification in the soil were measured yearly.



[Source: adapted from Monica G Turner: Inaugural Article "Inorganic nitrogen availability after severe stand-replacing fire in the Greater Yellowstone ecosystem" (2007) *PNAS*, **104**(12), pages 4782–89: Figure 3 copyright 2007 National Academy of Sciences, USA]

(a) (i) Identify the years when the most ammonification occurred. *[1]*

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(ii) Calculate the net nitrogen level in the soil for the year of the Moran fire. *[1]*

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(b) State the name of **one** bacterium that could be responsible for nitrification levels. *[1]*

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(This question continues on the following page)

(Question F1 continued)

(c) Using the data, explain what could account for the low levels of ammonia after the Moran fire. *[3]*

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F2. (a) (i) List **two** microscopic eukaryotes. *[1]*

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(ii) Outline the diversity of microscopic eukaryotes. *[3]*

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(b) State **two** microbes used for the production of **two named** foods. *[2]*

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(c) Explain the use of bacteria in bioremediation for **one** specific substance contaminating soil **or** water. *[2]*

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F3. Discuss the origin and epidemiology of **one named** example of a pandemic. *[6]*

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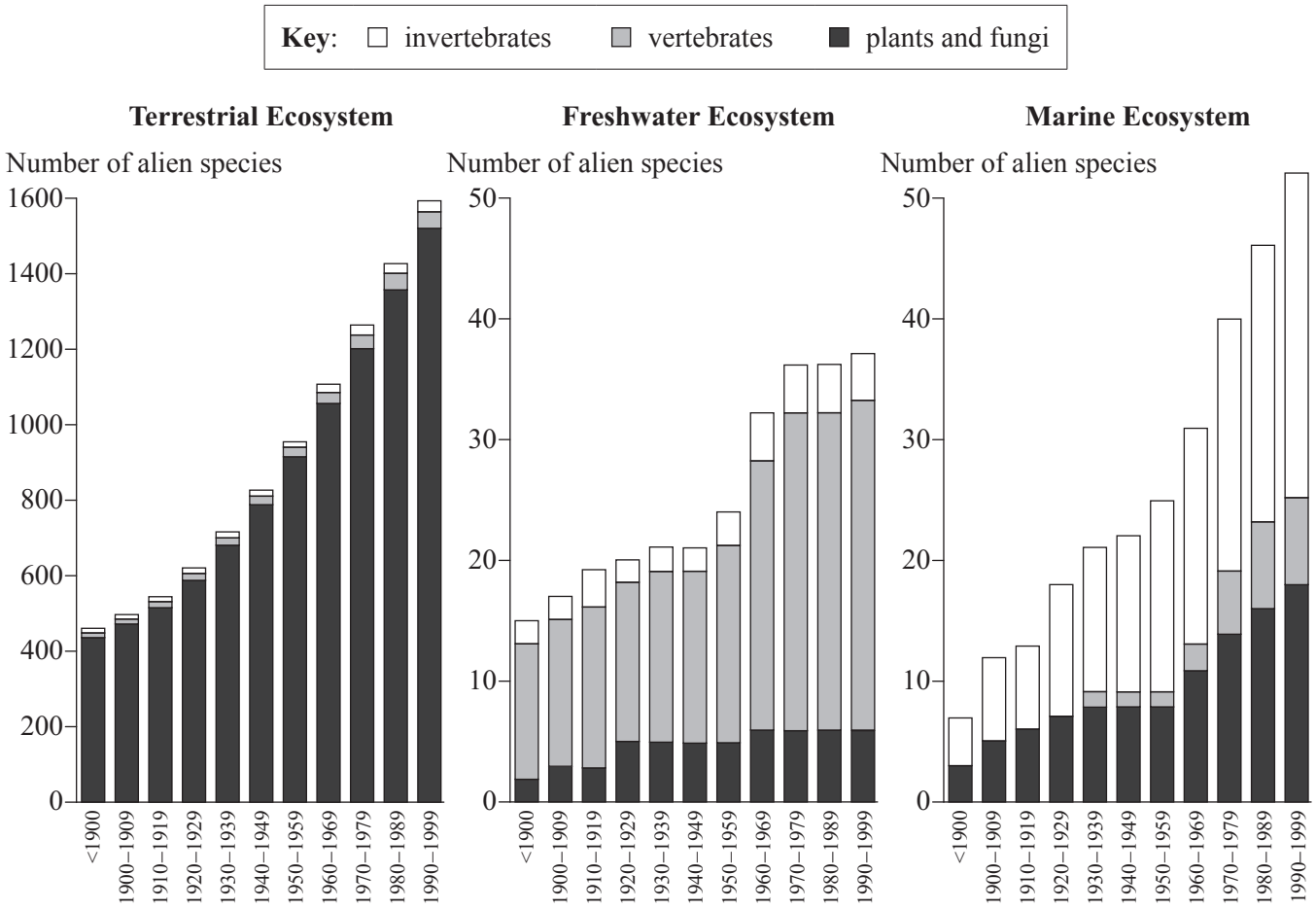
Option G — Ecology and conservation

G1. Invasion of alien species has become a serious issue in most environments of the world. This study of Nordic environments charts the presence of alien species over the last century. Relative proportions of invertebrates, vertebrates and plants and fungi are indicated in each bar.



[Source: adapted from I. R. Weidema (ed), *Introduced Species in the Nordic Countries*, © Nordic Council of Ministers 2000, Copenhagen, Nord 2000:013, ISBN 92-893-0489-8]

(a) (i) State the ecosystem in which the proportion of alien vertebrates is the greatest. *[1]*

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(ii) Describe the general pattern of the numbers of alien species in terrestrial and marine ecosystems. *[1]*

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(This question continues on the following page)

(Question G1 continued)

(b) Suggest a reason why alien plant and fungi invasion is greatest in the terrestrial ecosystem. *[1]*

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(c) Identify how invasion of marine waters by alien invertebrates might occur. *[1]*

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(d) Discuss the impact of alien species on ecosystems. *[3]*

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G2. (a) Distinguish between fundamental niches and realized niches. *[2]*

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(b) Outline the changes in species diversity and production during primary succession. *[2]*

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(c) Outline, using examples, the biogeographical features of nature reserves that promote the conservation of diversity. *[3]*

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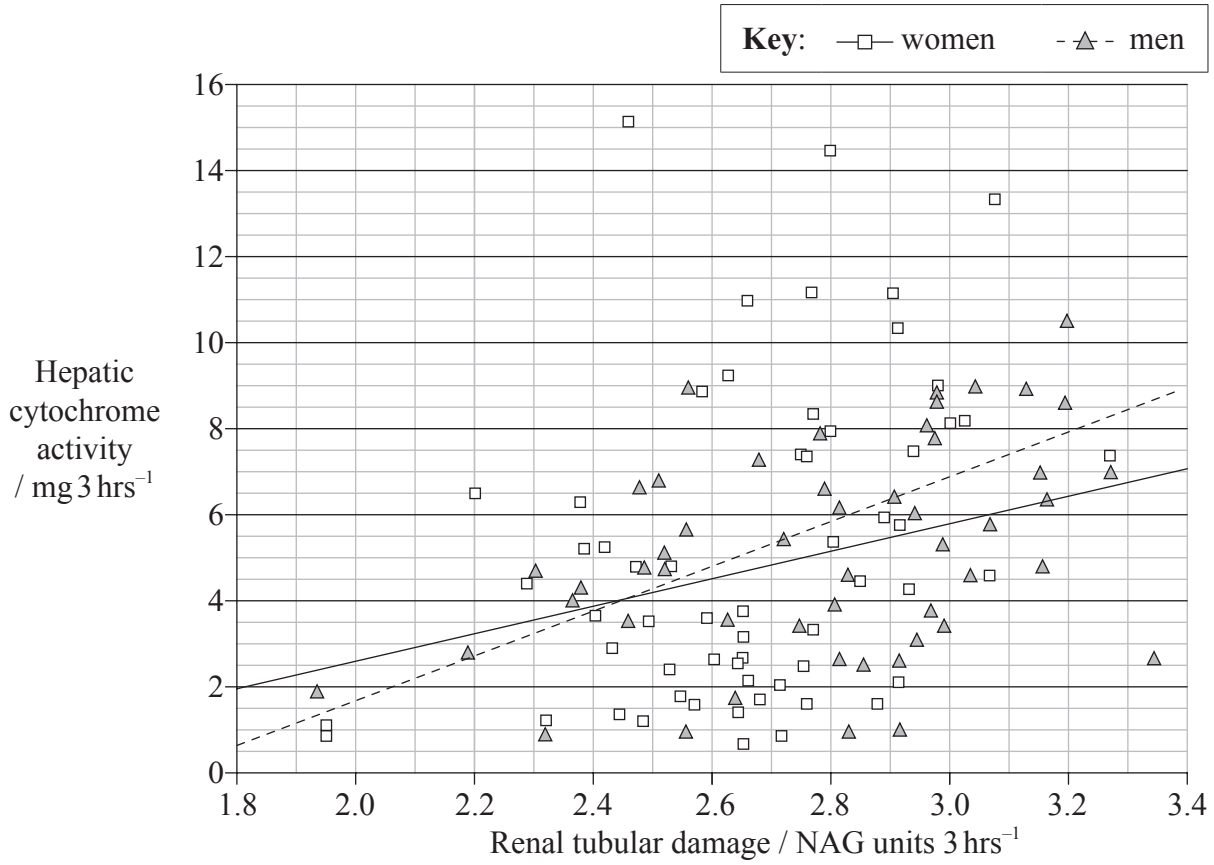
G3. Discuss international measures that would promote the conservation of fish. *[6]*

Option H — Further human physiology

H1. A group of non-smoking men and women were studied for the effects of environmental contamination with cadmium, a toxic metal. A study was conducted to see the effect of cadmium exposure on the metabolism of the liver, as measured by the activity of a cytochrome enzyme that metabolizes drugs, and on renal tubular damage in the kidney as indicated by the excretion of a substance, NAG.



[Source: adapted from S. Satarug *et al*., "Evidence for concurrent effects of exposure to environmental cadmium and lead on hepatic CYP2A6 phenotype and renal function biomarkers in nonsmokers", *Environmental Health Perspectives*, 2004, **112**(15), pages 1512-1518, Figure 2. Reproduced with permission from Environmental Health Perspectives]

(a) (i) Identify the highest hepatic cytochrome activity value in women. *[1]*

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(ii) Identify the lowest renal tubular damage value in men. *[1]*

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(This question continues on the following page)

(Question H1 continued)

(b) Compare the correlation between hepatic and renal functions for men and for women. *[2]*

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(c) The scientists who conducted the study hypothesized that exposure to cadmium causes toxicity in both hepatic and renal functions. Using the data, evaluate the hypothesis. *[2]*

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H2. (a) Distinguish between the mode of action of protein hormones and steroid hormones. *[2]*

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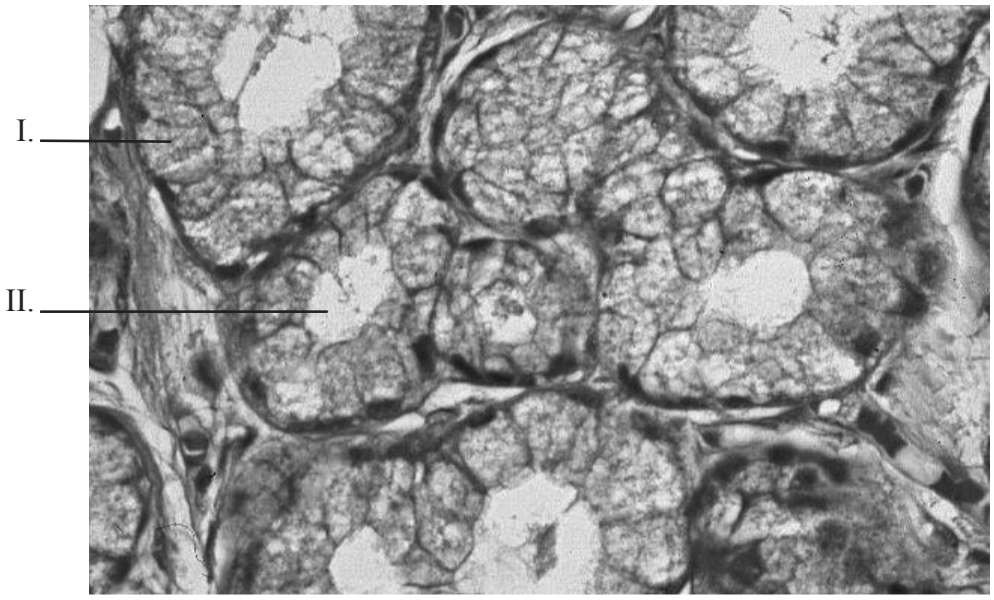
(b) Label the indicated structures in the micrograph of exocrine gland cells below. *[2]*



[Source: www.pathguy.com/histo/074.jpg. Reprinted with the permission of Ed Friedlander, Kansas City University of Medicine and Biosciences.]

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(Question H2 continued)

(c) Outline the control of the secretion of gastric juice by nerves and hormones. *[4]*

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H3. Explain, with the use of a diagram, the role of the Bohr shift in the supply of oxygen to respiring heart muscle. *[6]*